The Hera Milani Mission

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CTO, Tyvak International

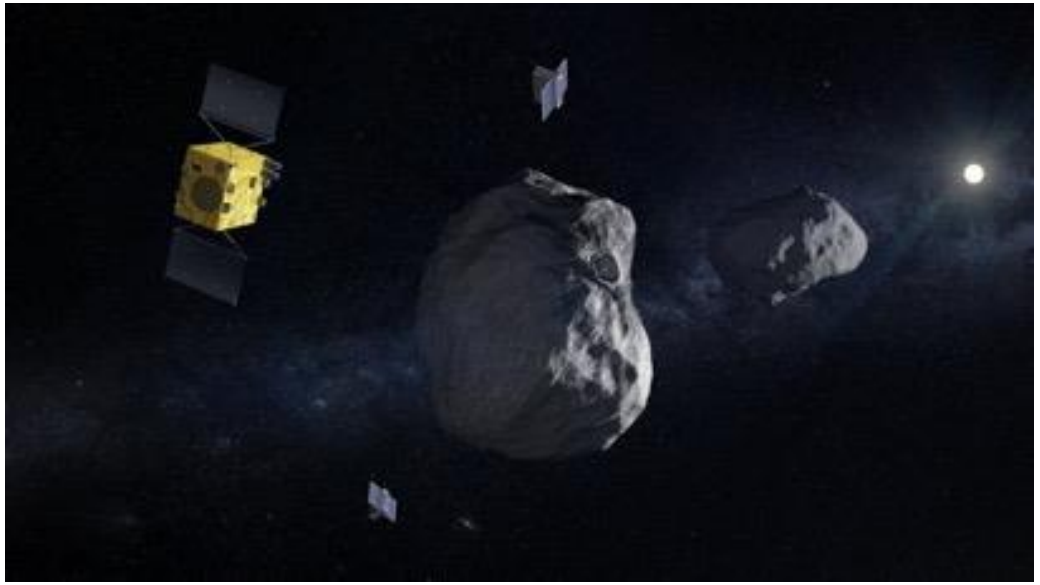
Tyvak International
A Terran Orbital Corporation

Hera Mission

- **Asteroid Impact & Deflection Assessment (AIDA) collaboration**
- **Asteroid Impact**
  - NASA Mission “DART”
  - Impact 26 Sept 2022
- **Asteroid inspection after impact**
  - ESA Mission “Hera”
  - Launch 2024
  - Mission 2026/2027
- **Hera mission includes two Nanosatellites**
  - Juventas
  - Milani (Tyvak International)

Milani Consortium

- **Customer:**
  - European Space Agency
- **Industrial team**
  - **Tyvak International**: **Prime contractor**
    - platform developer, spacecraft integrator, SVT with Hera, launch services, operations
  - **12+ sub-contractors**
    - from Italy, Czech Rep, Finland



TYVAK INTERNATIONAL
PRIME CONTRACTOR
Space Segment Developer

POLIMI
Mission and GNC design

ALTEC
Space-to-Ground Interface

VTT
ASPECT Payload Provider

INAF
VISTA Payload Provider

GLI
DPU software requirements & testing

UNI HELSINKI
ASPECT Calibration

POLITO
Requirements and environmental analysis

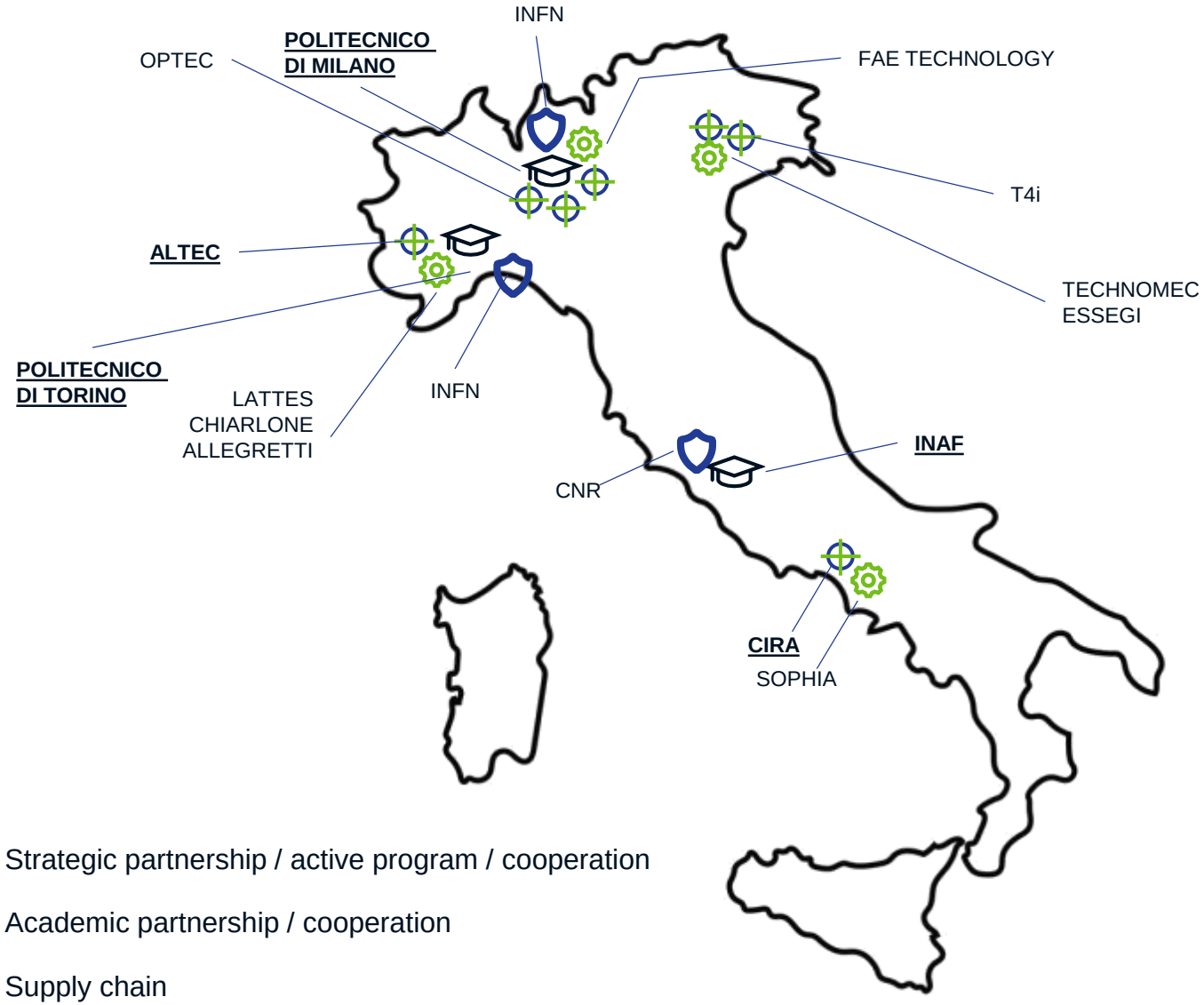
CIRA
Environmental Test

KUVA SPACE
ASPECT DPU Provider

HULD
Software Development

UNI BRNO
ASPECT on board algorithms

Italian representatives (consortium, partners, supply chain)



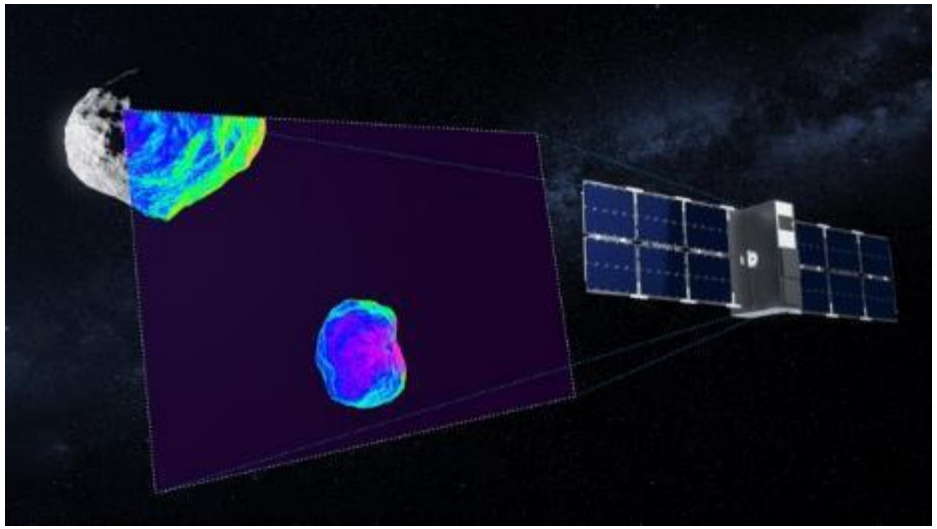
- Strategic partnership / active program / cooperation
- Academic partnership / cooperation
- Supply chain
- Institutional relations

- Mission analysis, GNC and Image Processing algorithms, Navigation Experiment
- Requirements, debris analysis, radiation activities
- VISTA Payload
- Ground Segment Interfaces definition
- Qualification test at “Laboratorio di Qualifica Spaziale” (Tyvak heritage)
- Provision of retroreflectors
- Joint development (Tyvak and T4I) of the Milani propulsion system (“Ianus”), leveraging on the Perseus development
- Provision of NavCam lenses optimized for Milani mission

Milani Scientific objectives

- **Milani aims at enhancing the overall Hera scientific return**
- **Milani scientific objectives:**

1. **Asteroid imaging - Map the global composition and characterize the surface of the Didymos asteroids**
   - Main Payload: **ASPECT**



Hyperspectral imaging

2. **Dust detection - Characterize dust clouds around the Didymos asteroids**
   - Secondary Payload: **VISTA**

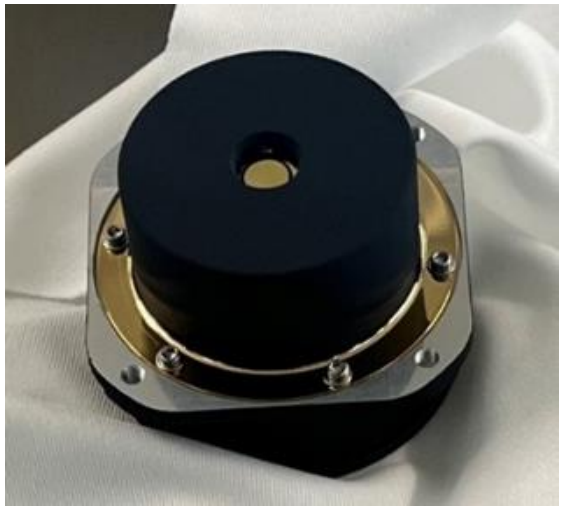
DUST detection

Milani payloads and scientific goals

- **ASPECT (VTT, Finland)**
  - ASP SG1 - Imaging both the asteroids with a spatial resolution better than 2 m/pixel
  - Imaging the secondary asteroid with a spatial resolution better than 1 m/pixel
  - Imaging the DART crater with a spatial resolution better than 0.5 m/pixel at phase angle (Sun-asteroid-Milani angle) in the range [0-10] deg and [30-60] deg.

Parameter	Value
Total Mass	1,5 kg
Power consumption during acquisition	13-14W
Data Volume	4.7 Gbit

- **VISTA (Istituto Nazionale AstroFisica, Italy)**
  - VIS SG1 – Detect the presence of dust particles smaller than 10μm
  - VIS SG2 – Characterization of volatiles and light organics desorbed by the sensor surface;
  - VIS SG3 – Molecular contamination monitoring, coming from outgassing processes on-board the spacecraft/CubeSat hardware components.



Parameter	Value
Total Mass	90 g
Power	< 0.85 W (passive mode) < 1.5 W (active mode)
Data Volume	1.6 Mbit

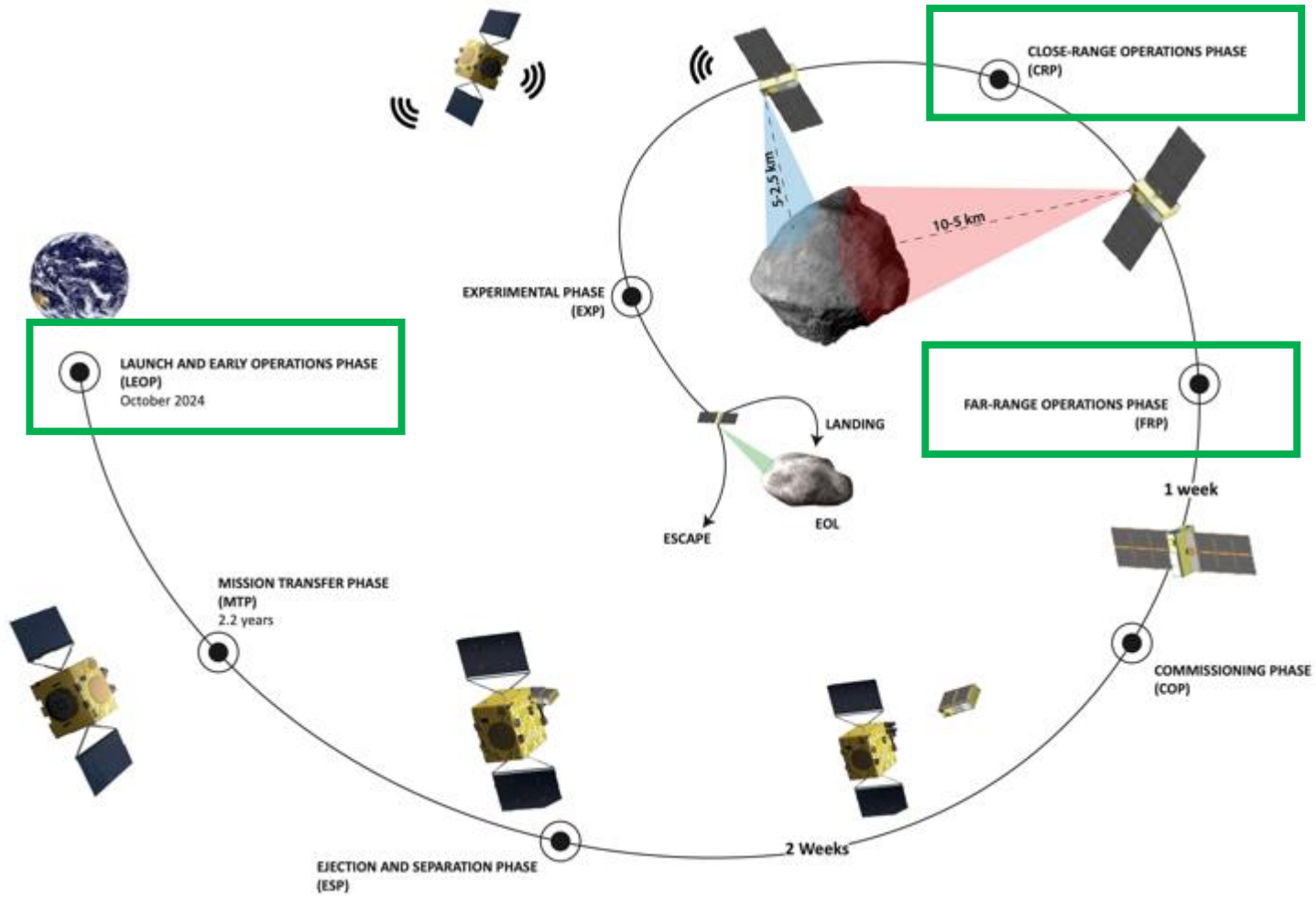
Milani Mission Overview

- **Milani integrated into Hera mothercraft**
- **Mission phases**
  - Launch and Near-Earth Commissioning
  - Cruise phase (ca 2 years)
  - Deployment and nominal mission (far range and close range)

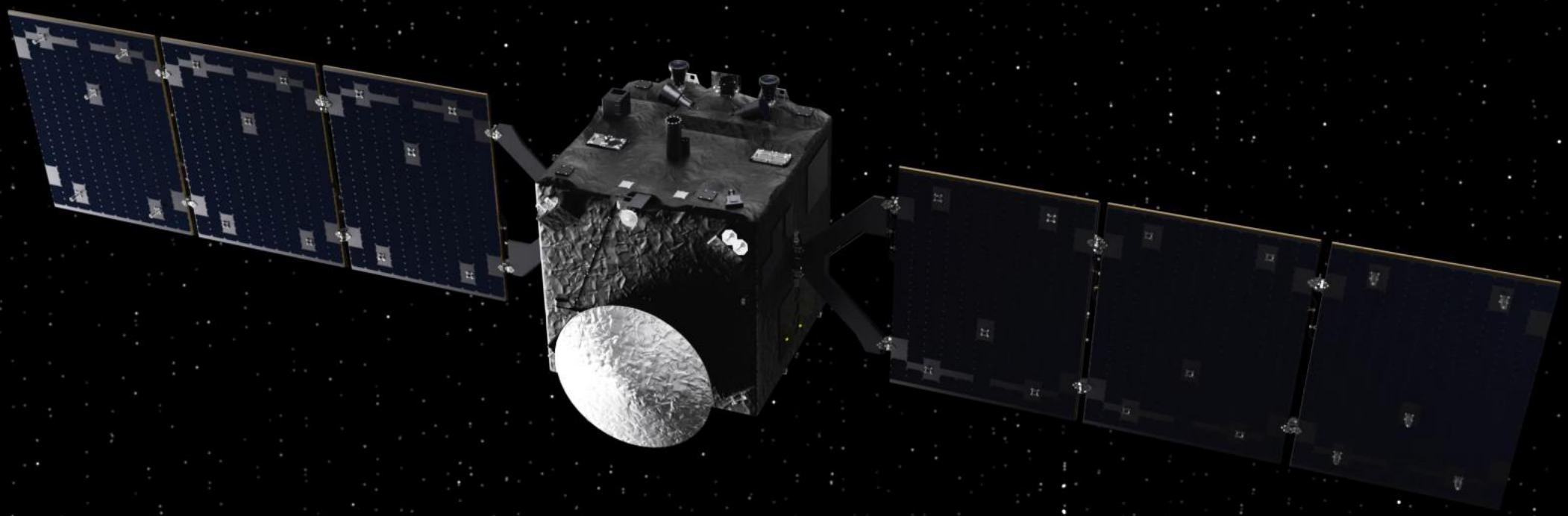
- **Far Range Phase (FRP)**
  - Distance: **11 km** from D2 surface.

- **Close Range Phase (CRP)**
  - Distance: less than **3 km** from D2

- **Milani's communication with ground will be performed via Inter-Satellite Link (ISL) using Hera as data relay.**



Milani mission designed by Politecnico di Milano



Milani satellite technologies: focus

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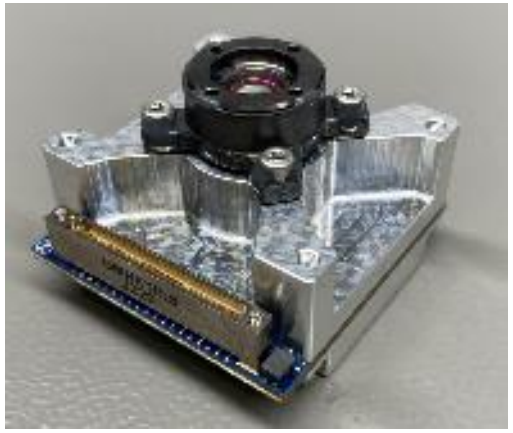
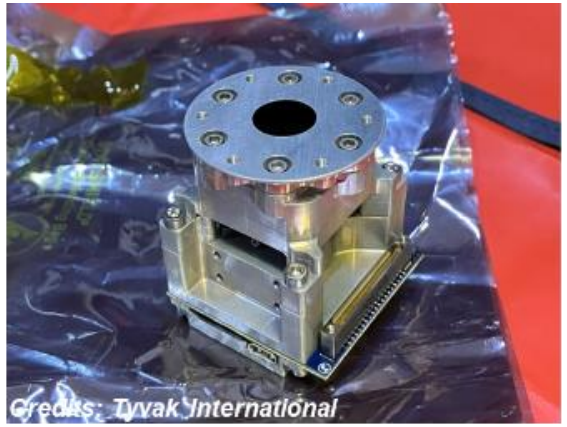
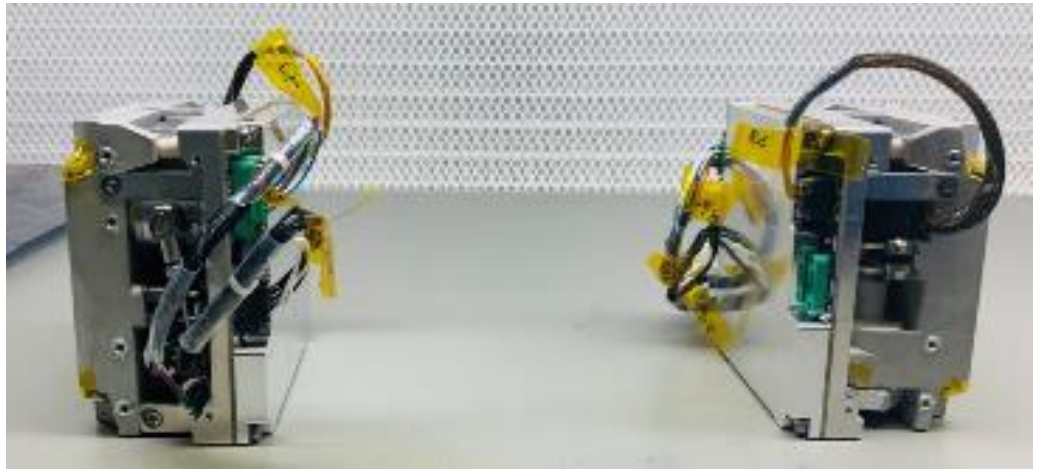
- **Navigation Camera**
  - Navigation camera developed by **Tyvak**
  - Lens optimization: **Optec (Italy)**
  - IP and GNC Algorithms: **Politecnico di Milano (Italy)**





Feature	Capability
Sensor	Tyvak ProxOps Vis Imgs WFOV RGB
Resolution	116mm @500m distance 464mm @2km distance 2.32 @10km distance
Angular FOV	21x16deg
Horizontal FOV	185m @500m distance 740m @2km distance 3.7km @10km distance
Sensor size	2048x1536 px
Pixel size	2.20 um
Focal lenght	13mm

- **Propulsion System (”Ianus”, Cold gas)**
  - Joint development by Technology for **Propulsion and Innovation (T4I, Italy) and Tyvak International**

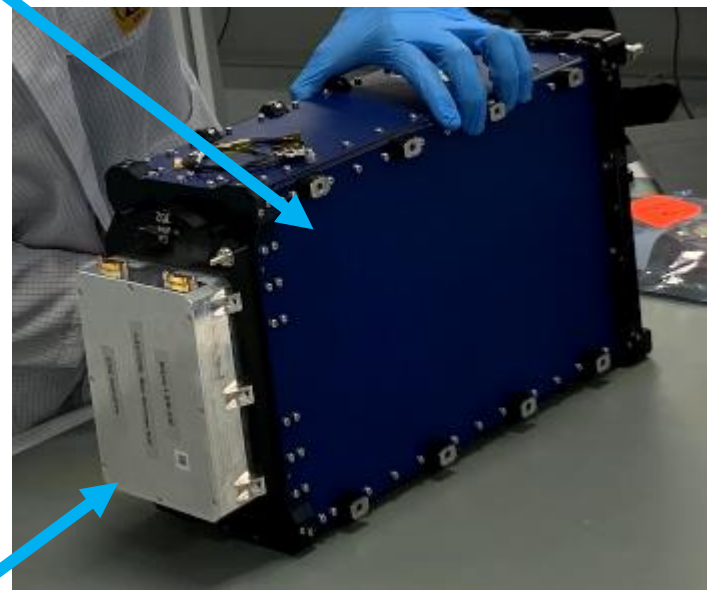


Specification	Capability
Number of modules	2 (identical)
Envelope (each module)	100x95x60mm
Mass (per module)	600g
Total Impulse (per module)	38 Ns
Power (per module)	2W stand-by, <30W peak power, 20W firing
Max continuous impulse	6.0 Ns in <300s
Specific Impulse	>40s
Leakage	< 1e-6 SCCS of Helium total
Time-to-fire	<5mins
Thrust level	9.2mN(x), 10.8mN(y), 26.4mN(z)
Degrees-of-freedom	6

Hera Milani interfaces validation

- **Overall Hera Milani System configuration**
  - Milani integrated into the Hera main spacecraft for launch and cruise
  - Multiple interfaces to be managed (common to the whole mission spacecraft)

Deep Space Deployer (DSD), provided by ISIS
Milani-to-Hera interface during launch and cruise phase



Life Support Interface Board (LSIB)
Deployer-to-Hera interface

Milani vehicle Engineering Model

Cubesat Interface Bracket (CIB), provided by ISIS
Milani-to-deployer interface

Hera Milani interfaces validation

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- **Two models developed to validate interfaces with Hera mothercraft**
  - Reduced EM (“rEM”)
  - Structural and Thermal Interface Model (“STIM”)

Hera Milani interfaces validation

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  - Reduced EM (“rEM”)
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- **Reduced EM**
  - Reduced set of Satellite avionics for data and power interfaces validation
  - Preliminary interfaces testing at Tyvak premises with Hera simulator
- **Status**
  - Test campaign **successfully executed** in OHB with the Hera Avionic Test Bench (ATB) to test main electrical and software functionalities (including ISL)

Hera ATB – Milani rEM test campaign at OHB

Hera Milani interfaces validation

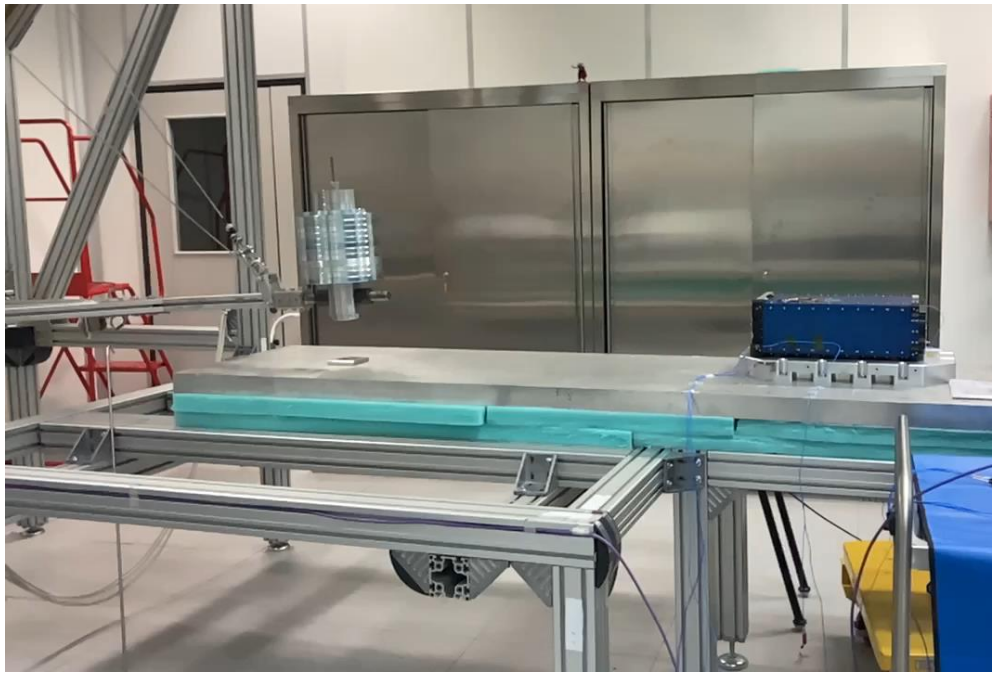
- **Two models developed to validate interfaces with Hera mothercraft**
  - Reduced EM (“rEM”)
  - Structural and Thermal Interface Model (“STIM”)

- **Structural and Thermal Interface Model (“STIM”)**
  - Reduced set of Satellite avionics and dummy masses for mechanical and thermal interfaces validation
  - To be used for the execution of the Hera qualification test campaign
- **Status:**
  - STIM Qualification **completed**
  - Integration into Hera **completed**
  - Hera EVT **completed**
  - **Nominal** STIM functionalities

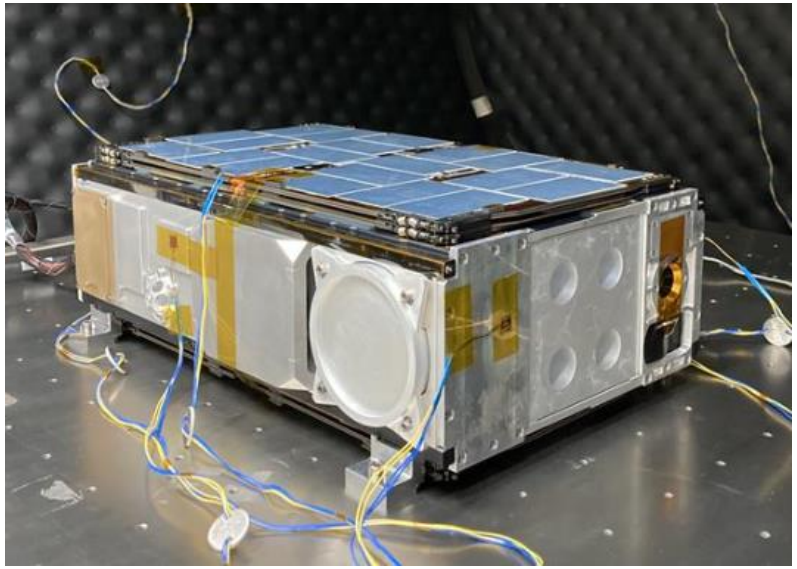
MILANI STIM Integration in Hera

Credits: OHB

STIM Environmental test at CIRA (Italy)

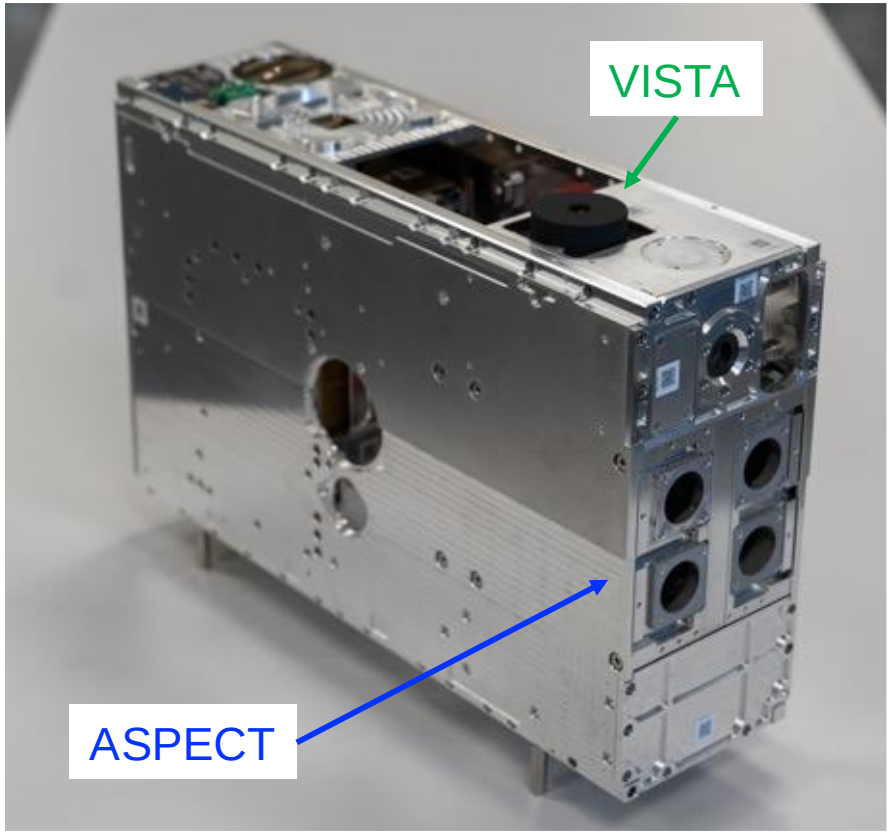


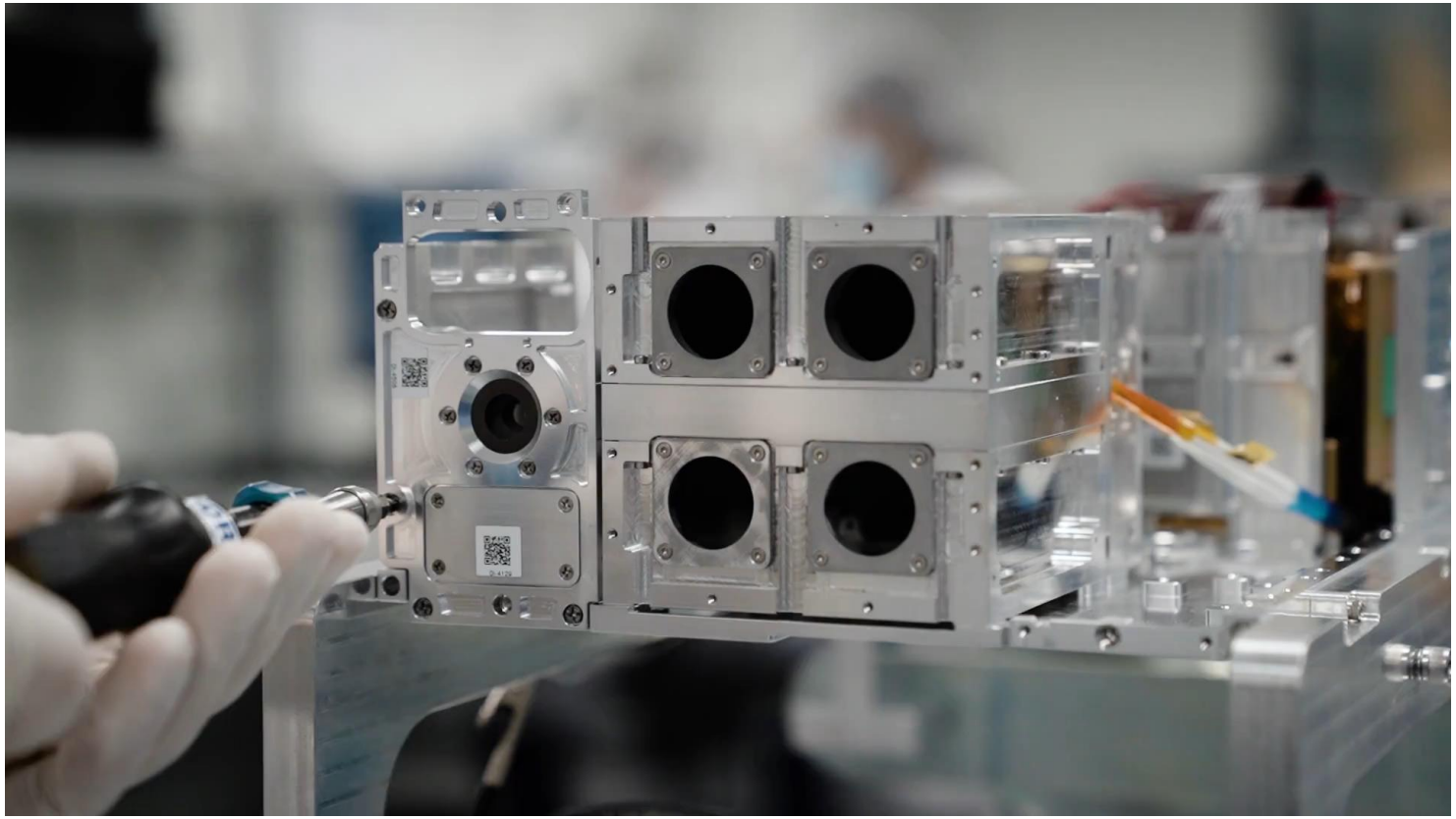
MILANI STIM in TVAC Chamber



Milani Engineering Model

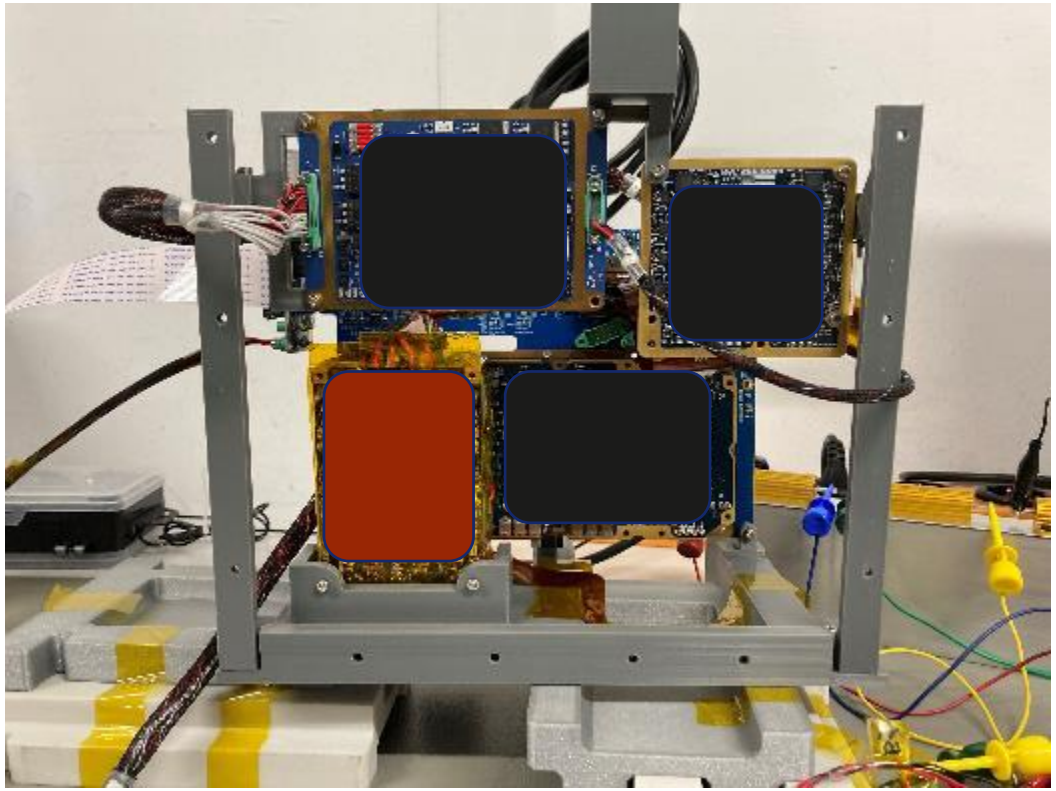
- **Engineering Model**
  - Mechanical Fit check
  - Internal interfaces validation
  - EMI EMC Campaign
    - H and E field radiated emission &susceptibility test, DC Magnetic momentum measurement
- **Status: completed**

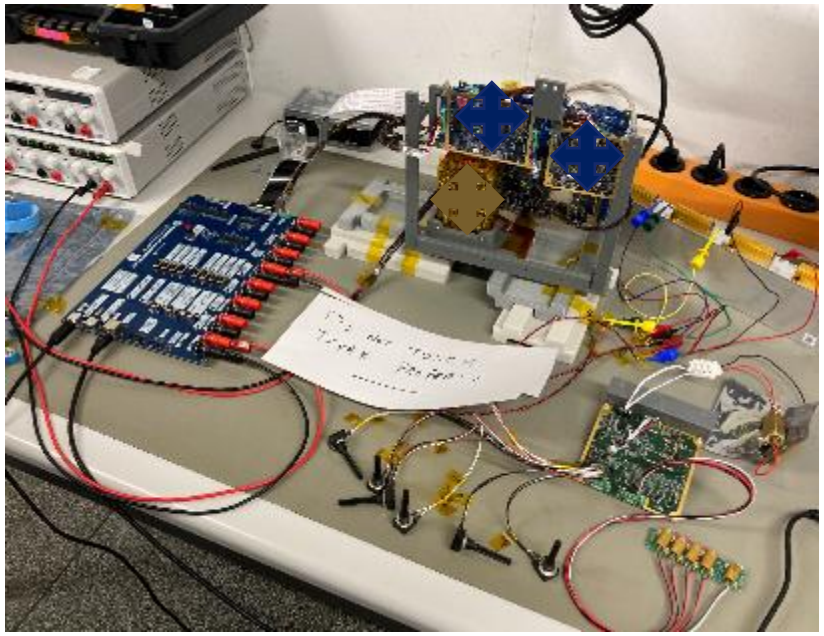




Radiation assurance

- **Radiation hardness campaign**
  - Ensure the mission execution in a deep space environment
  - **Heavy ion test** on components and **high energy proton** on modules
  - Managed by Tyvak with support of Politecnico di Torino





High Energy Proton test campaign

Milani ProtoFlight Model

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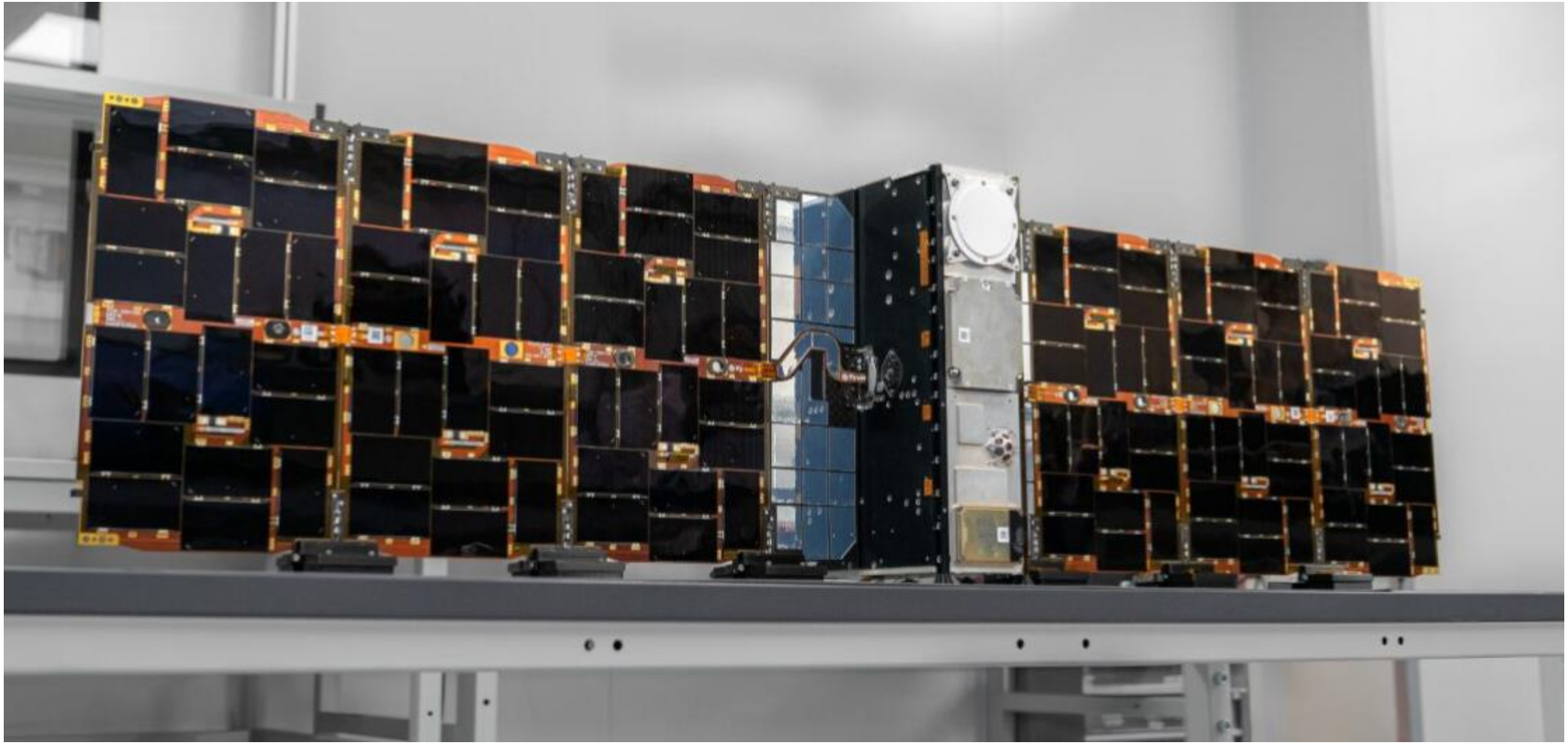
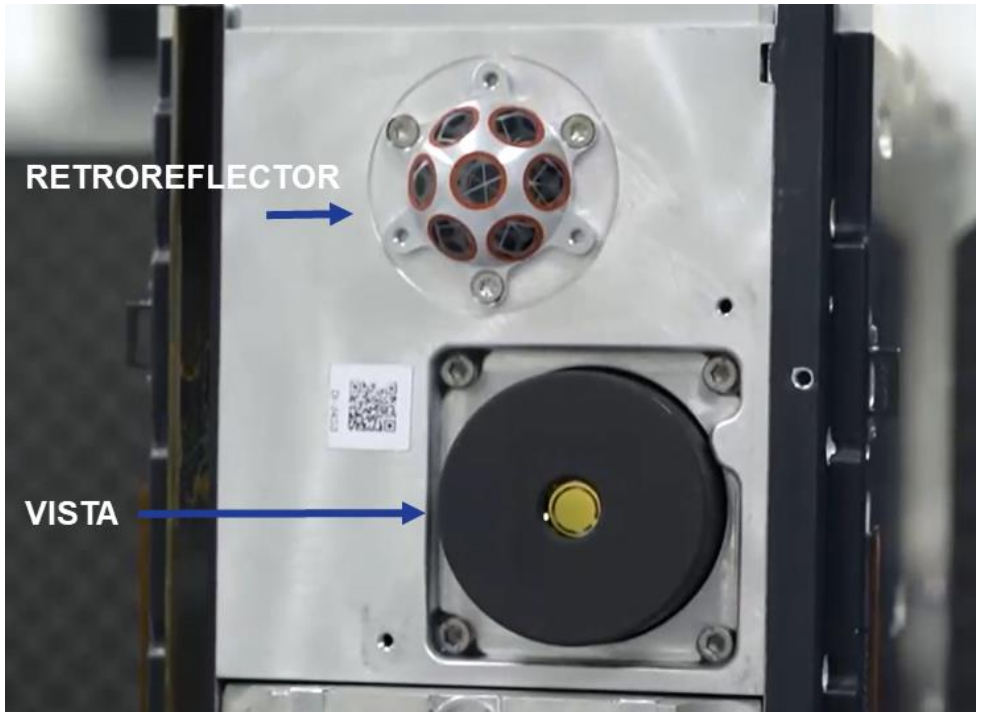
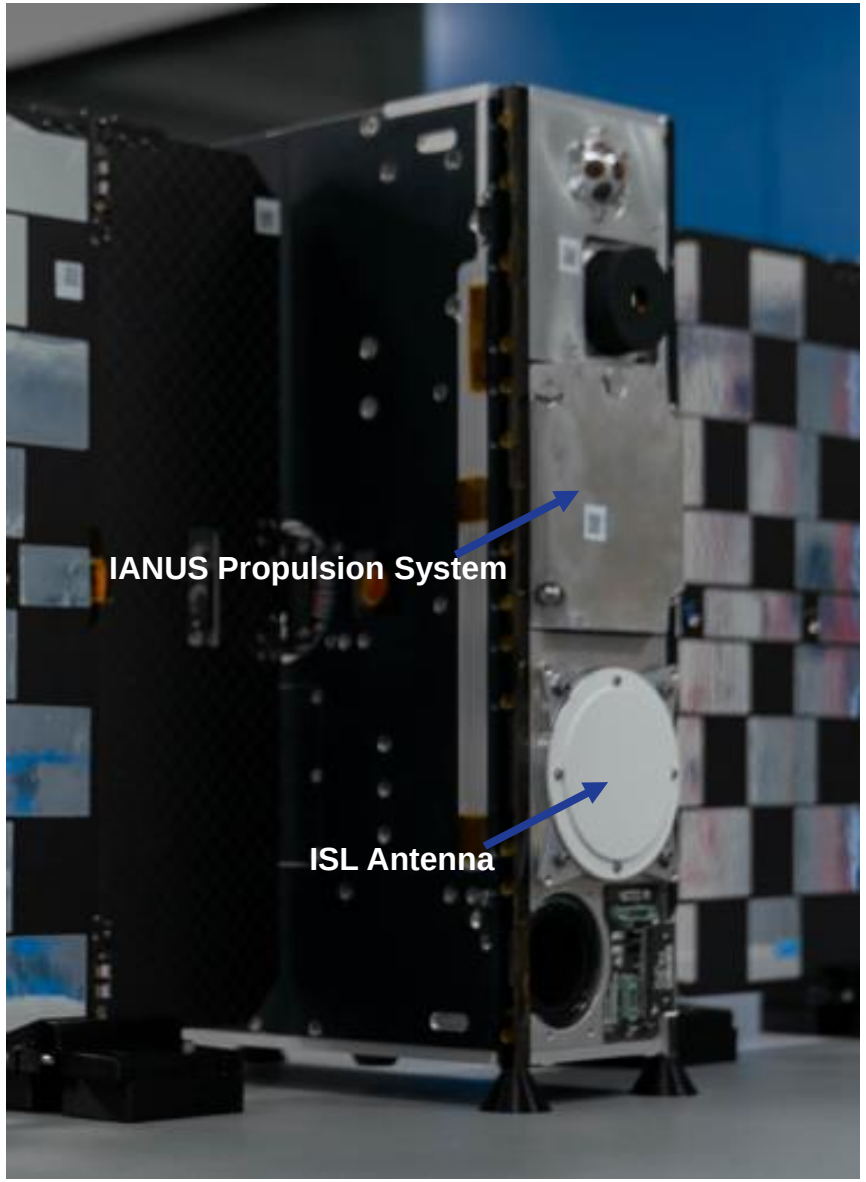


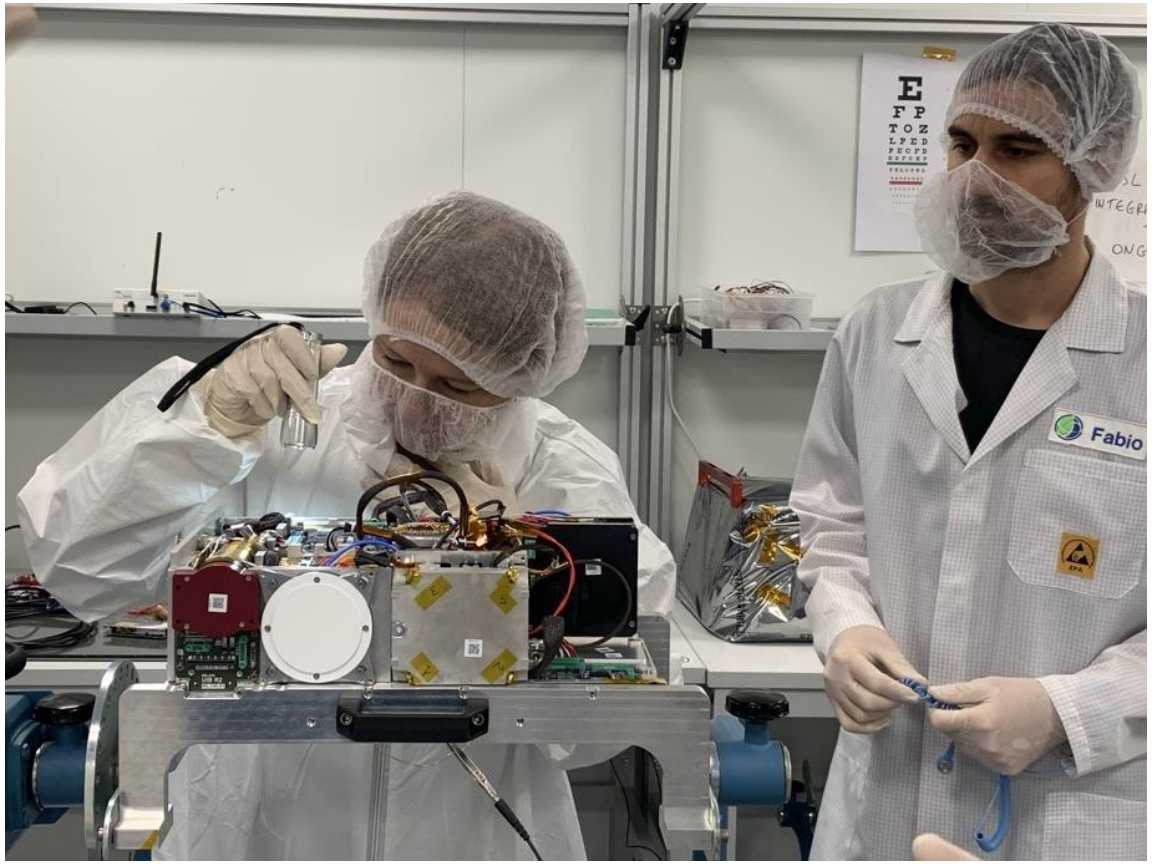
Milani ProtoFlight Model





Milani ProtoFlight Model Build

- **ESA Quality Inspection before final closure**

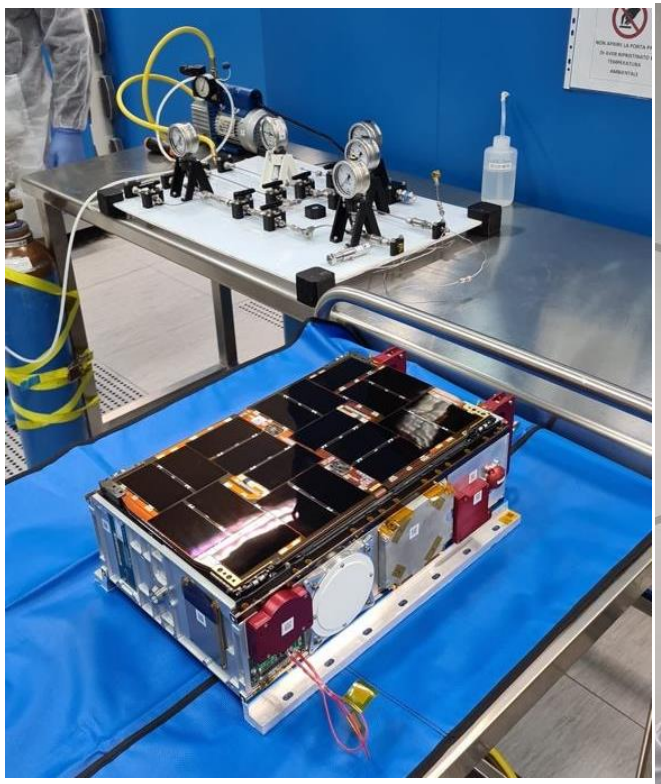


Milani ProtoFlight Model Build

- **ESA Quality Inspection before final closure**

Milani PFM Environmental Test Campaign

- **Environmental Test Campaign completed at CIRA (Capua, Italy)**
  - Vibration tests (random, sine, QSL) along the three axis

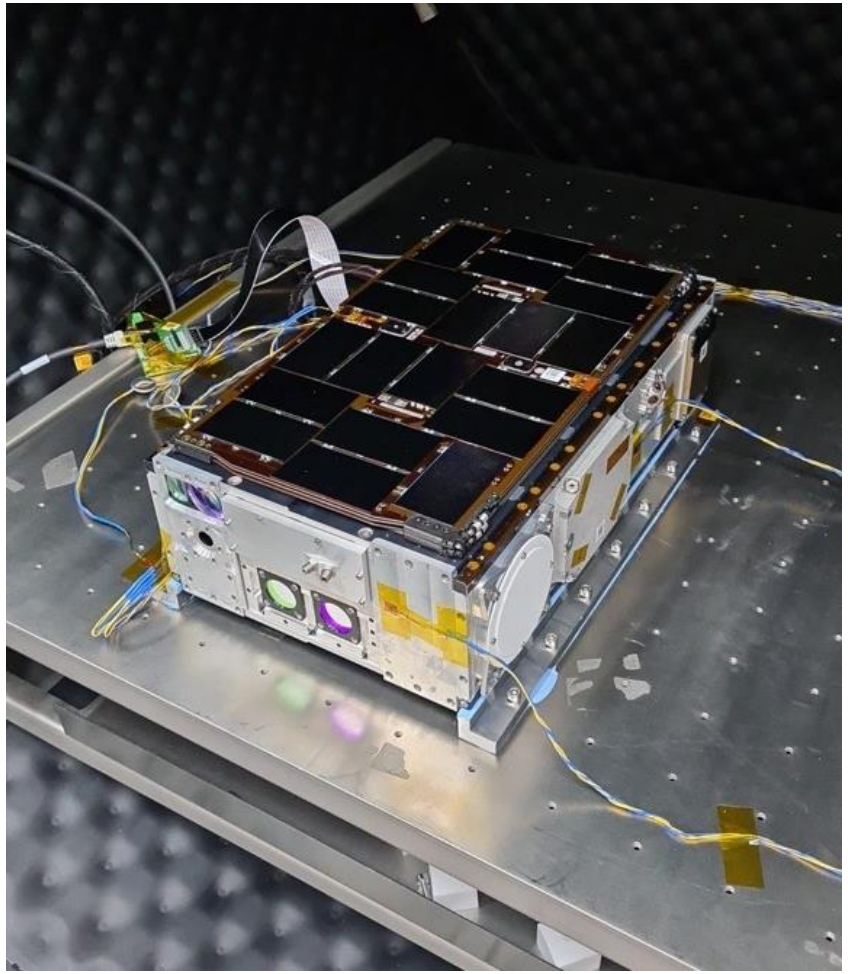


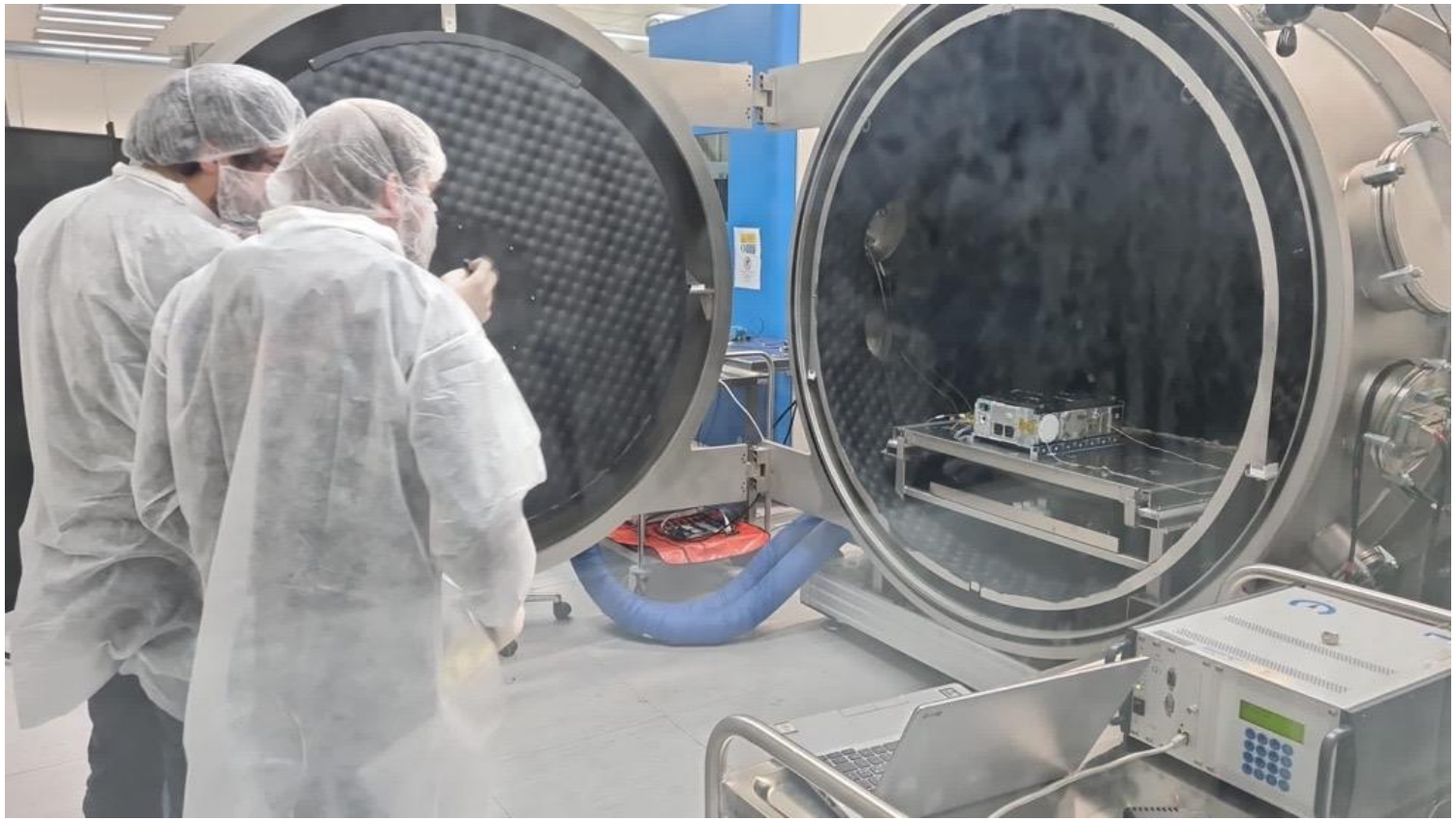
Propulsion System (IANUS) loading with He

Integration into the Deep Space Deployer

Milani PFM Environmental Test Campaign

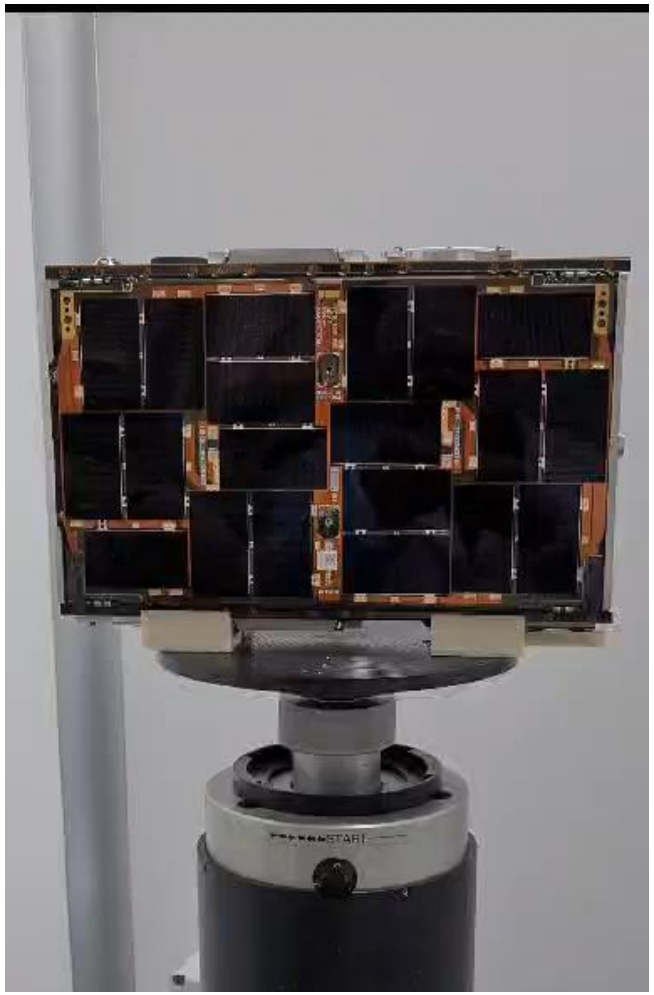
- **Environmental Test Campaign completed at CIRA (Capua, Italy)**
  - Thermal Vacuum (bakeout, cycles, Ianus leak test, ASPECT FPI tests)



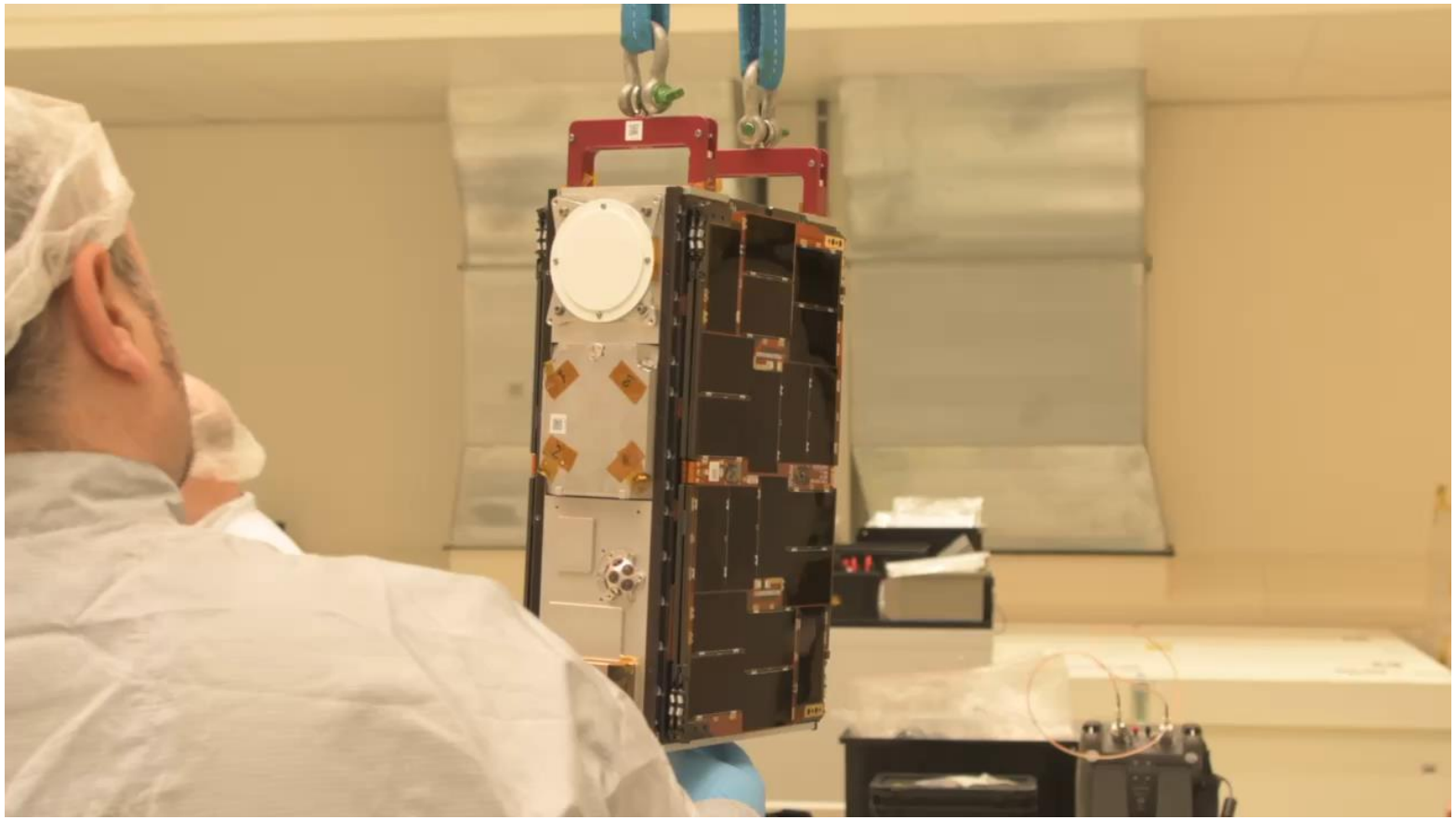


Milani PFM Environmental Test Campaign

- **Environmental Test Campaign completed at CIRA (Capua, Italy)**
  - Mass Properties measurements (mass, CoG, MoI, PoI)



Milani PFM First mating with Hera (March 2024)



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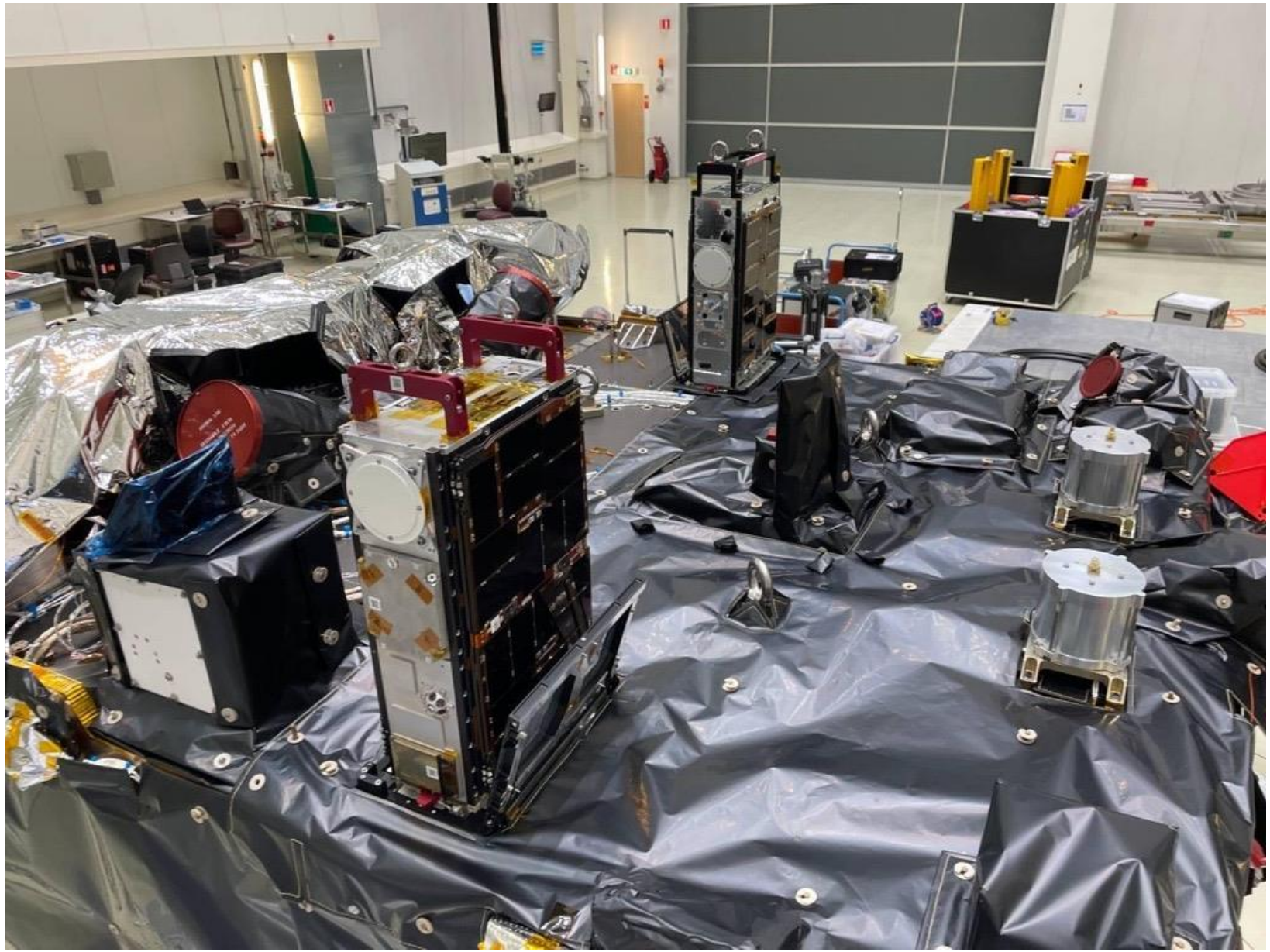
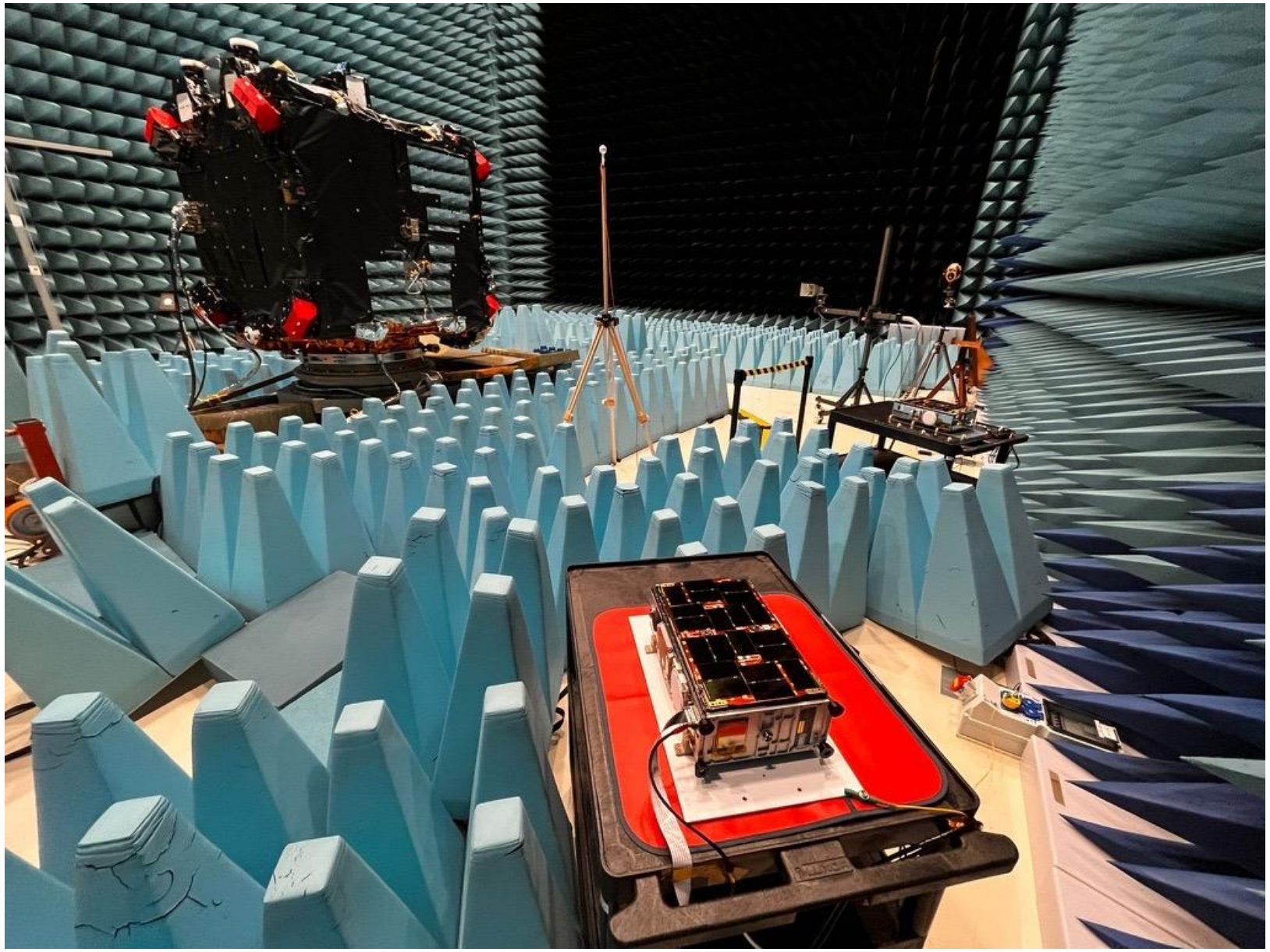


- **Stowing executed**
- **Deployment command tested**
- **First ISL communication tested**

Autocompatibility and SVT (April 2024)



- **Autocompatibility tests**
- **SVT with Ground Segment (Hera Mission Operations Center - ESOC)**

Conclusions

- **Milani CubeSat was developed in 3 years from KO to Qualification**
- **Multiple technologies (including propulsion system, navigation camera, Intesatellite Link, mission specifics interfaces, etc.), as well as payloads (ASPECT, VISTA) and four vehicle models were developed**

- **Launch campaign (September 2024)**
- **Launch (October 2024)**

Thanks to Tyvak International and whole Milani team!!

A step closer to Didymos!!

Flawless Execution Sustains Growth

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